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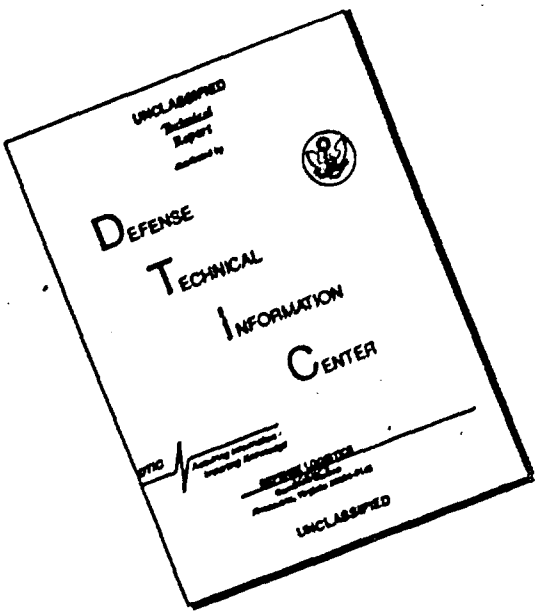

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THE EFFECT OF WICK MATERIAL ON THE IGNITION OF DIESEL FUEL BY STATICALLY DETONATED 3.5 INCH HEAT ROCKET HEADS (U)

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DEVELOPMENT AND PROOF SERVICES

13th Report OCO Project No. TB3-1224B

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THE EFFECT OF WICK MATERIAL ON

THE IGNITION OF DIESEL FUEL BY

STATICALLY DETONATED 3.5 INCH HEAT ROCKET HEADS

THIRTEENTH REPORT ON PROJECT TB3-1224B (U)

THIS DOCUMENT CONSISTS OF 20 PAGES

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DEVELOPMENT AND PROOF SERVICES
ABERDEEN PROVING GROUND
MARYLAND

AUTHORITY: Memo, BRL to D&PS, 8 Feb 1955
PRIORITY: 1A

Lt Stemann/vl
17 May 1956

THE EFFECT OF WICK MATERIAL ON THE IGNITION OF DIESEL FUEL BY STATICALLY DETONATED 3.5 INCH HEAT ROCKET HEADS

THIRTEENTH REPORT ON PROJECT TB3-1224B (U)

DATES OF TEST: February 1955 to August 1955

OBJECT

The object of this test is to determine the effect of a wick material comprising a mixture of grease, sand, and oil in tank engine and fuel compartments on the ignition of diesel fuel by 3.5 inch HEAT, M28A2, Rocket Heads.

SUMMARY

A total of 60 rounds was detonated against simulated fuel containers placed behind the 80mm thick sponson armor of German Royal Tiger tank hulls. Data were obtained on ambient and diesel oil temperatures previous to firing, and on the type and frequency of resulting fires.

CONCLUSION

Diesel fuel fire frequency is affected to a much greater extent by variations in fuel temperature than by the presence of the wick material, as tested.

RECOMMENDATION

It is recommended that comparative tests be conducted to determine conclusively the effect of other wick materials such as rubber hoses, electrical wiring and radiator cores at various fuel temperatures.

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I INTRODUCTION

A. DISCUSSION

1. Previous tests of 3.5 inch HEAT rounds against diesel fuel indicated that the presence of wick material was a factor in the ignition of the oil (reference Fifth Report on TB3-1224B). Since collections of sand, dirt, oil and grease are frequently found on or near most tank engines, it was decided to simulate this condition and to determine its effect on fire frequency.

2. During the firing of the first 30 charges, the target fuel temperatures varied between 20° and 63°F and the ambient temperature between 37° and 68°F. The results of these firings indicated the effect of temperature was greater than that of the wick material. Accordingly, the test was extended to encompass firings at very high summer temperatures.

B. REFERENCES

1. Memo, BRL to D&PS dated 8 February 1955, Subject: Continuation of Diesel Fuel Firings. (See Appendix A)

2. The Ignition of Diesel Fuel by Statically Detonated 3.5 HEAT Rocket Heads, Armor Test Report No. AD-1188, Fifth Report on Project No. TB3-1224B.

II DESCRIPTION OF MATERIEL

A. The target hulls were originally for the German Royal Tiger tank. The fuel containers were mounted inside and against the sponsons of these hulls.

B. Fuel Containers: Box, Steel, M2, No. 16, U.S. Standard gauge, Drawing No. 76-4-53, obtained from salvage yards and hereinafter referred to as "powder cans".

C. Ammunition: 60 Rocket Heads, 3.5 inch HEAT, M28A2, Lots COP-SR-5-14, COP-SR-4-12, COP-SR-4-32, COP-SR-4-95.

D. Diesel Fuel (See Appendix B):

1. 425 Gal.; Diesel Index 45.6, Flash Point 135°F

2. 425 Gal.; Diesel Index 43.4, Flash Point 162°F

E. Wick Material: A local mixture containing, by volume; 50% sand, 25% #90 grease, 12-1/2% diesel fuel, 12-1/2% #50 oil.

III DETAILS OF TEST

A. PROCEDURE

1. The first 30 rounds were detonated against unaltered German Tiger tank hulls (see Appendix C, photographs of standard test setup taken from Fifth Report on TB3-1224B). Powder cans approximately 7/8ths full of diesel fuel were placed in the tank fuel compartment and held flush with the 80mm thick sponson armor. The mixture of sand, grease and oil (wick material) was smeared on the bottom and walls of the fuel compartment. The rocket heads were statically detonated at 0° obliquity to the armor, at built-in (ogive) standoff, by means of a blasting machine.

2. Thirty rounds were detonated at high summer temperatures. For this phase of the test it was necessary to alter the Tiger tank hulls. These had been fired on many times. The hull fuel compartment was lengthened along the side of the tank, making more of the sponson armor available as a target surface. Except for this, the test conditions were similar to those for the previous tests against unaltered hulls.

3. Static detonation of the 3.5 inch HEAT rocket heads was accomplished by means of a Corps of Engineers special blasting cap inserted in a tetryl pellet in the fuze cavity of the rocket head, as in previous tests.

B. RESULTS

1. The fires which occurred varied considerably in size and intensity, and were classified as follows:

a. Large fire: enveloped large portion of hull with intensely burning fuel and continued to burn.

b. Medium fire: relatively small areas of burning fuel which were able to continue burning and spread throughout the tank hull.

c. Small fire: small pools of burning fuel or a single isolated flame which never increased in intensity. Such fires often did not continue to burn.

2. While any fire is dangerous, it is the first two types described above which would most likely result in complete immobilization of a vehicle. Thus, in evaluating the test results, the small fires were ignored.

3. Complete round-by-round data is presented in Appendix D. The following is a summary of the results:

TABLE I

FUEL TEMP. RANGE (°F)	NO. OF ROUNDS	NO. OF FIRES	PERCENTAGE OF FIRES
20° - 42°	22	4	18%
54° - 63°	8	3	37%
88° - 97°	30	18	60%

4. An absolute comparison between the results of this and previous tests can not be made. Earlier work on the ignition of diesel fuel by shaped charges showed that there was an important temperature effect. Only ambient temperature, rather than ambient and oil temperatures, was recorded, however. Assuming the two temperatures were in the same general range on any specific day, the following comparisons can be made:

TABLE II

TEMP. RANGE °F	PERCENTAGE OF FIRES (with wick material)	PERCENTAGE OF FIRES (without wick material) From 5th Report on TB3-1224B
20° - 42°	18%	10% (approx.)
over 60°	-	40% (approx.)
88° - 97°	60%	-

5. The data indicates fire frequency was increased relatively little by the wick material as used and applied in this test. The data also indicates that increases in fuel temperature caused an appreciable increase in the fire frequency.

C. OBSERVATIONS

The effect of wind conditions in spreading fires was noted during the tests conducted at high summer temperatures. Fires of medium size, just after the detonation of the HEAT round, quickly spread, under favorable wind conditions, to engulf the entire fuel and engine compartments of the Tiger tank hulls.

IV CONCLUSIONS

A. The wick material, as tested, was not markedly effective in increasing fire frequency.

B. The effect of temperature on fire frequency is very pronounced. Under the conditions of this test approximately twice as many fires occurred at high fuel temperatures as did at low fuel temperatures.

V RECOMMENDATIONS

A. Similar tests should be conducted against a setup more closely simulating tank conditions in order to reveal the wick action effects of radiator cores, rubber hoses and electrical wiring as well as of the grease-dirt material used in this test.

B. When variables that affect fire frequency are being investigated, the tests should be conducted at as near constant fuel temperatures and atmospheric conditions as possible.

A. Pillersdorf
for L. G. STEMANN
Lt, Ord Corps
Proof Officer

APPROVED:

Benjamin S. Goodwin
BENJAMIN S. GOODWIN
Assistant Director for Engineering Testing
Development & Proof Services

H. L. Rosenberg
H. L. ROSENBERG
Chief, Terminal
Ballistic Division

APPENDICES

APPENDIX A

Memorandum

Director, ERL to Director, D&PS, 8 Feb 1955

COPY/vl

THRU : Chief, Weapon Systems Laboratory
Director, Development and Proof Services

Mr.GBeichler/ah/26225
8 February 1955

Director, Ballistic Research Laboratories

Continuation of Diesel Fuel Firings

1. It is requested that Development and Proof Services continue firings into diesel fuel to study the effects of wick material on the probability of igniting diesel fuel. The following conditions should be maintained:

a. Attacking Projectile - 3.5" M28A2 Heat Projectile - statically fired.

b. Targets

(1) 16 gallons powder cans 7/8 full of diesel fuel placed behind 3/4" of the armor of German Tiger Tank hulls flush with inside armor surface.

(2) 16 gallons powder cans 7/8 full of diesel fuel behind 3" of armor in the prototype fuel container.

c. Wick material - a mixture of diesel fuel, dirt and sand spread over the floor area of both targets to simulate the engine compartment of a tank.

d. Conditions - all rounds to enter the fuel container at approximately the same distance below the fuel level.

e. Temperature - Fuel temperatures are to be taken of the fuel and all firings are to occur at fuel temperatures between 20° to 50° F.

2. A preliminary test of six rounds is to be fired at each target. If no fires occur or all fires occur the firings are to stop. If mixed conditions occur further firings will continue until a sufficient sample size is obtained.

3. All fires are to be classified the same as the gasoline fires as noted in Par. 3 of BRL Memo to Dir, D&PS, dtd 16 Nov 54, subj: "Vulnerability of Gasoline to the M28A2 HEAT Round".

4. Occasional meetings are desired between D&PS and BRL representatives to discuss problems that arise during the firings.

5. This program is classified 1A and is to be conducted under Project TB3-1224B, Work Order No. 962-002-00. All data pertaining to the results are to be classified CONFIDENTIAL.

/s/ F. E. G.

/t/ G. E. PARSONS, Jr.
Lt Colonel, Ord Corps
Assistant to Director
Ballistic Research Laboratories

APPENDIX B

Laboratory Reports

on Sample Analysis of Diesel Fuel

No. 6162 - 29 June 55

No. 6170 - 30 Aug 55

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ABERDEEN PROVING GROUND, MD.
PAINT & CHEMICAL LABORATORY
Laboratory Report

DATE: 29 June 1955

W.O. 962-002-00

IAB. NO. 6162

REF: Lt. Stemann
A&A Div, Armor Br.

ANALYSIS OF DIESEL FUEL USED AS TARGET FOR HEAT CHARGE

RESULTS

Diesel Index	45.6
Flash Point (°F)	135°F

REPORTED BY: C. Jackson
REVIEWED BY: M. Rosenfeld
APPROVED BY: C. F. Pickett /s/
C. F. PICKETT, Chief

13

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ABERDEEN PROVING GROUND, MD.
PAINT & CHEMICAL LABORATORY
Laboratory Report

DATE: 30 Aug 55 W.O. 962-602-70

REF: Lt. Stemann IAB. NO. 6170
Term. Ballistics (D&PS)

ANALYSIS OF DIESEL FUEL

RESULTS

FIASH POINT (OPEN CUP)	162°F
DIESEL INDEX	43.4

REPORTED BY: C. Jackson
REVIEWED BY: M. Rosenfeld
APPROVED BY: C. F. Pickett /s/
C. F. PICKETT, Chief

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APPENDIX C

Photographs

of Standard Test Setup

APG No. A-90653

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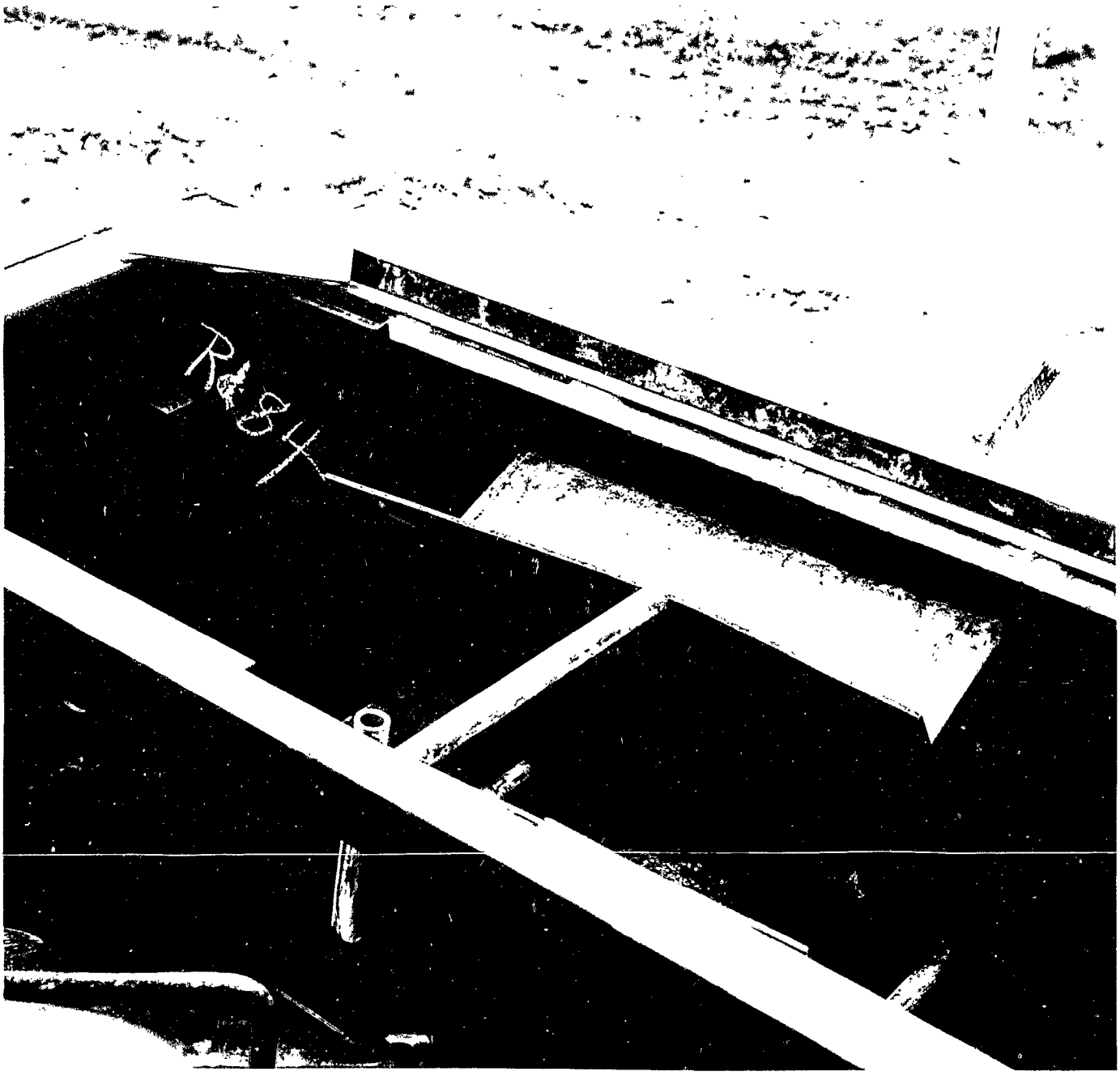

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Project No. TB3-1224B. Rocket Heads, 3.5", HEAT, vs Diesel Fuel. Container in tank hull behind 80mm armor at 20° obliquity before detonation.

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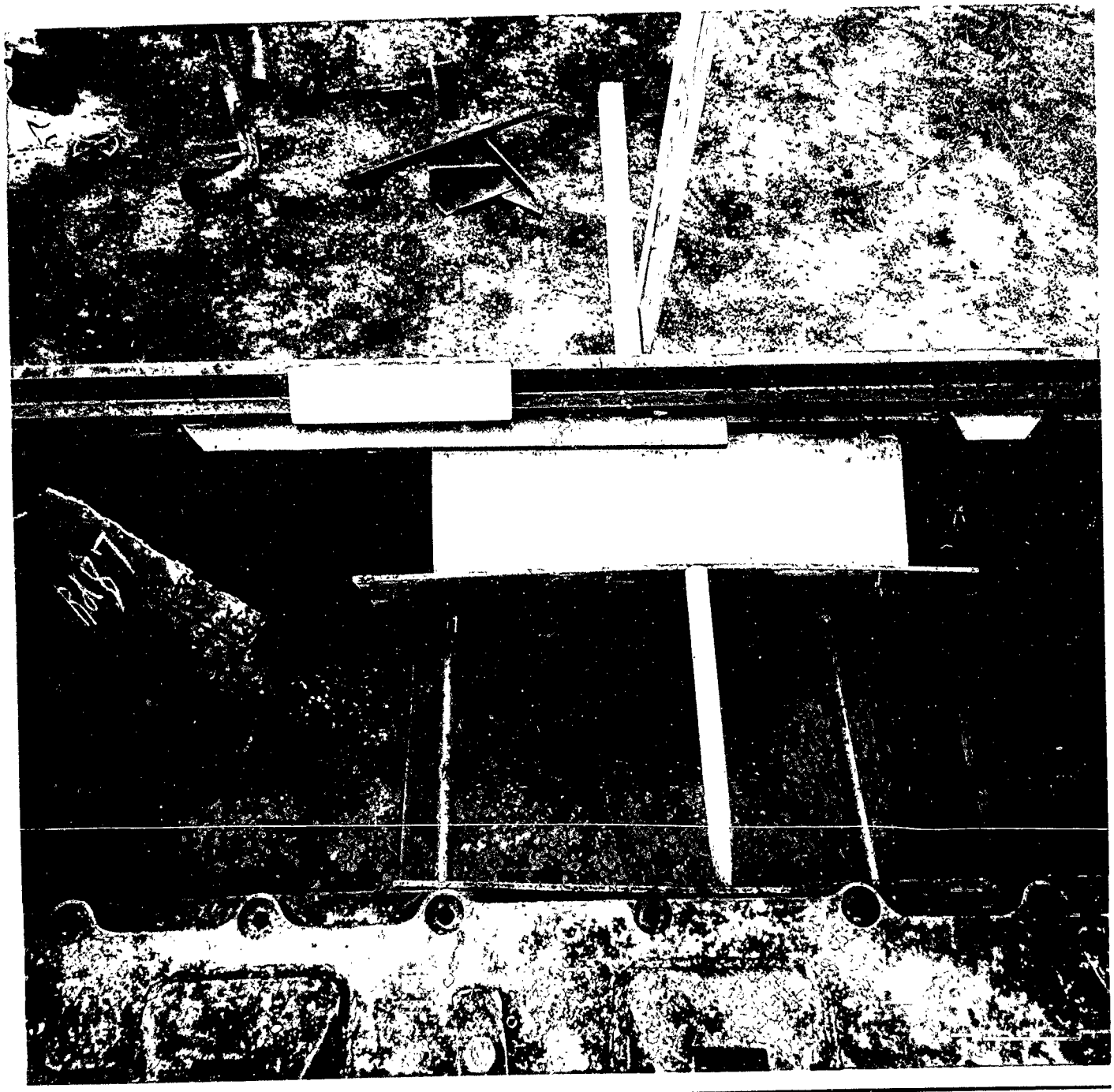

A90654 CONFIDENTIAL § ABERDEEN PROVING GROUND § 12 June 1953

Project No. TB3-1224B. Rocket Heads, 3.5", HEAT, vs Diesel Fuel. Container in tank hull behind 80mm armor at 20° obliquity before detonation.

APPENDIX D

Round-by-Round Data

ROUND-BY-ROUND DATA

3.5 Inch HEAT, M28A2 Rocket Head

vs

Diesel Fuel

Wick Material* Present in Fuel Compartment
*(50% Sand, 25% #90 Grease, 12-1/2% Diesel Fuel, 12-1/2% #50 Oil)

RD. NO.	FIRE (Y, N)	TYPE	LOCATION (compartment* in hull)	TEMP. FUEL °F	AMBIENT TEMP. °F
1	N	-	-	41	37
2	N	-	-	41	37
3	N	-	-	37	37
4	Y	Medium	Fuel	34	37
5	Y	Medium	Engine	34	37
6	Y	Large	All Over	54	60
7	Y	Large	All Over	54	60
8	Y	Small	Fuel	54	60
9	Y	Small	Engine	54	60
10	Y	Medium	Engine	37	68
11	N	-	-	35	68
12	N	-	-	42	68
13	N	-	-	28	68
14	N	-	-	32	68
15	Y	Small	Engine	35	53
16	N	-	-	33	53
17	N	-	-	28	53
18	N	-	-	28	53
19	Y	Small	Engine	28	53
20	N	-	-	38	45
21	N	-	-	40	45
22	N	-	-	38	45
23	Y	Small	Engine	40	45
24	N	-	-	40	45

ROUND BY ROUND DATA (CONTD)

RD. NO.	FIRE (Y, N)	TYPE	LOCATION (compartment* in hull)	TEMP. FUEL °F	AMBIENT TEMP. °F
25	Y	Large	All Over	21	63
26	N	-	-	20	63
27	N	-	-	55	63
28	N	-	-	63	63
29	Y	Medium	Engine	63	60
30	N	-	-	63	60
31	N	-	-	88	90
32	N	-	-	88	90
33	N	-	-	88	90
34	Y	Medium	Engine	88	90
35	Y	Medium	Fuel	88	90
36	Y	Large	All Over	95	95
37	Y	Medium	Engine	95	95
38	Y	Large	All Over	95	95
39	Y	Medium	Fuel	95	95
40	Y	Medium	Fuel	95	95
41	N	-	-	91	88
42	N	-	-	91	88
43	Y	Large	All Over	91	88
44	Y	Small	Fuel	91	88
45	Y	Medium	Fuel	91	88
46	Y	Small	Fuel	89	90
47	Y	Large	All Over	89	90
48	N	-	-	89	90
49	Y	Small	Engine	89	90
50	Y	Medium	Fuel	89	90
51	Y	Medium	Engine	97	95
52	N	-	-	97	95
53	Y	Medium	Engine	97	95
54	Y	Large	All Over	97	95
55	Y	Large	All Over	97	95
56	N	-	-	90	87
57	Y	Medium	Engine	90	87
58	N	-	-	90	87
59	Y	Large	All Over	90	87
60	Y	Medium	Fuel	90	87

* The target can was located in the fuel compartment.